Stability Improvement of Power System Using a Coordinated Systems FACTS-PSS, FACTS-MBPSS

Soufiane Lemdani, Mohammed Laouer, Ahmed Allali

***Abstract*—** This paper focuses on the significant of FACTS-PSS and FACTS-MBPSS to improve the transient stability of power system in various abnormal conditions. Simulations are carried out in Matlab/SPS environment for the two-area multi-machines power system model with SVC, STATCOM, SSSC and UPFC to analyze the effects of the proposed FACTS devices on transient stability of the power system. The performance of SVC, SSSC, STATCOM & UPFC is compared from each other. In comparative result UPFC, STATCOM, SSSC gives the better result than SVC in three phase fault, and UPFC is the most performed one .So for the improvement of transient stability UPFC & STATCOM is better than SVC and SSSC. The simulation results demonstrate the effectiveness and robustness of the proposed coordination FACTS-PSS and FACTS-MBPSS on transient stability improvement in the high power system.

***Keywords*—** *FACTS, MBPSS, PSS, Stability.*

I. INTRODUCTION

The development of the modern power system has led to an increasing complexity in the study of power systems, also presents new challenges to power system stability, and in particular, to the aspects of transient stability and small-signal stability [1]. Transient stability control plays a significant role in ensuring the stable operation of power systems in the event of large disturbances and faults [2].The recent development of power electronics introduces the use of flexible AC transmission system (FACTS) controllers in power systems [2], [3]. FACTS controllers are capable of controlling the network condition in a very fast manner and this feature of FACTS can be exploited to improve the voltage stability, and steady state and transient stability of a complex power system [4], [5]. Nowadays, the power system stabilizer (PSS) is widely used by power system utilities. Generally, it is important to recognize that machine parameters change with loading make the machine behavior quite different at different operating conditions. Since these parameters change in a rather complex manner, a set of stabilizer parameters, which stabilizes the system under a certain operating condition, may no longer yield satisfactory results when there is a drastic change in power system operating conditions and configurations [7]. Hence, SVC, SSSC, STATCOM, and UPFC should provide some degree of robustness to the Variations in system parameters, loading conditions, and configurations. In some case PSS, MBPSS are fail to maintain the stability of power system, so that are use the FACTS device, which give additional support to maintain the stability of power system. So we are show the effect of FACTS_PSS and FACTS_MBPSS in this paper.

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II. SYSTEM MODEL

THIS PAPER SIMULATION OF A COMMON SYSTEM MODEL CONSISTS OF TWO SYNCHRONOUS GENERATORS:

A. Generator

Fig.1 show the two-area system used in the study. The system consists of two different areas. Each area includes two generating units equipped with fast static exciters. All two generating units are represented by the same dynamic model.

Generation G1: Nominal power 1000MW, line-to-line voltage 13,8kV, frequency 50Hz.
Generation G2: Nominal power 5000MW, line-to-line voltage 13,8kV, frequency 50Hz.

B. Transformer

Three-phase transformer T1:1000MVA, 13.8 kV/500 Kv.
Three-phase transformer T2: 5000MVA, 13.8kV/500 Kv.

C. Load

Load1: Three-Phase Parallel RLC Load P=5000 MW.

D. SVC, STATCOM

To maintain system stability after faults, the transmission line is shunt compensated at its center by a 200 Mvar static var compensator (SVC), or a 200 Mvar Static Synchronous Compensator (STATCOM). SVC and STATCOM are two shunt devices of the Flexible AC Transmission Systems (FACTS) family using power electronics to control power flow and improve transient stability on power grids. The SVC regulates voltage at its terminals by controlling the amount of reactive power injected into or absorbed from the power system. When system voltage is low, the SVC, STATCOM generates reactive power (SVC, STATCOM capacitive). When system voltage is high, it absorbs reactive power (SVC, STATCOM inductive).

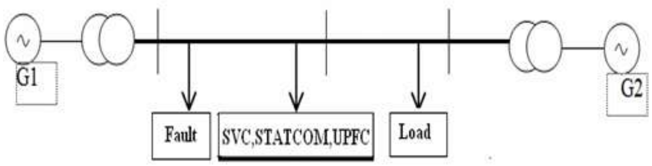

Fig. 1. System model

E. STATIC VAR COMPENSATOR (SVC)

Static VAR compensator systems are applied by utilities in transmission applications for several purposes. The primary purpose is usually for rapid control of voltage at weak points in a network. Installations may be at the midpoint of transmission interconnections or at the line ends. Static VAR Compensators are shunting connected static generators absorbers whose outputs are varied so as to control voltage of the electric power systems. In its simple form, SVC is connected as Fixed Capacitor Thyristor Controlled Reactor (FC-TCR) configuration as shown in Fig.2

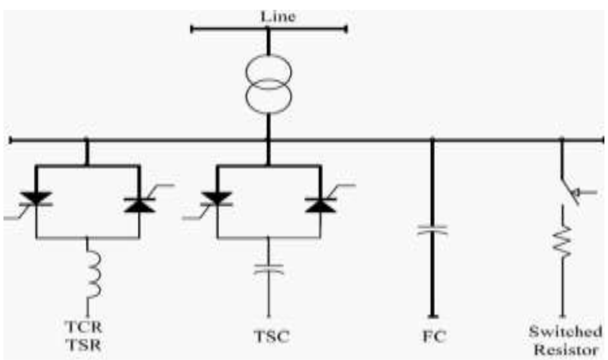

Fig. 2. Static VAR Compensator of SVC

The SVC is connected to a coupling transformer that is connected directly to the AC bus whose voltage is to be regulated. The effective reactance of the FC-TCR is varied by firing angle control of the anti-parallel thyristors. The firing angle can be controlled through a PI (Proportional + Integral) controller in such a way that the voltage of the bus, where the SVC is connected, is maintained at the reference value.

F. Static synchronous compensator

The STATCOM is based on a solid state synchronous voltage source which generates a balanced set of three sinusoidal voltages at the fundamental frequency with rapidly controllable amplitude and phase angle. The configuration of a STATCOM is shown in Fig.3.

Basically it consists of a voltage source converter (VSC), a coupling transformer and a DC capacitor

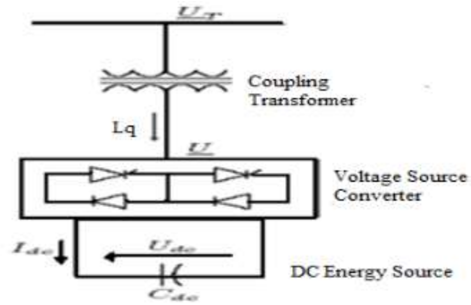

Fig. 3. Static Synchronous Compensator (STATCOM)

G. Unified power flow controller (UPFC)

Unified power flow controller is a device nothing but a combination of series & shunt FACTS device & it obviously do the same work what is done by the series & shunt FACTS device alone. It is the most powerful FACTS device [7]. UPFC is mainly a combination of SSSC & STATCOM. Use to improve the transient stability of the power system [8]. The schematic figure of unified power flow controller is given below

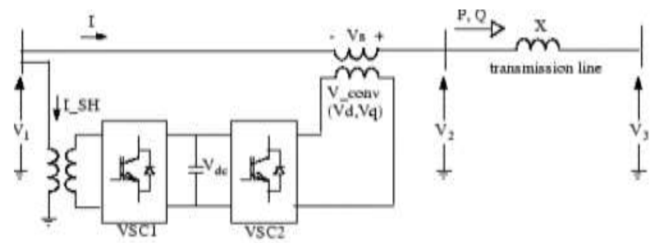

Fig. 4. Unified power flow controller

H. Generic Power System Stabilizer

The Generic Power System Stabilizer (PSS) block can be used to add damping to the rotor oscillations of the synchronous machine by controlling its excitation. The disturbances occurring in a power system induce electromechanical oscillations of the electrical generators. These oscillations, also called power swings, must be effectively damped to maintain the system stability [9], [10]. The output signal of the PSS is used as an additional input (vstab) to the Excitation System block. The PSS input signal can be either the machine speed deviation, dw, or its acceleration power, Pa = Pm - Pe (difference between the mechanical power and the electrical power).

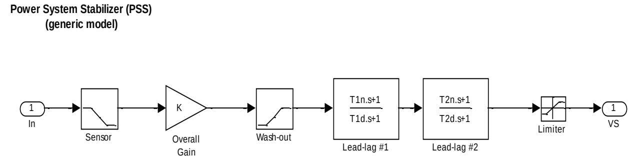

Fig. 5. Delta w PSS

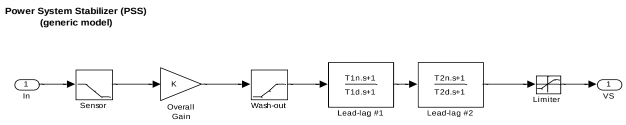

Fig. 6. Delta Pa PSS

I. Multiband power system stabilizer

The disturbances occurring in a power system induce electromechanical oscillations of the electrical generators. These oscillations, also called power swings, must be effectively damped to maintain the system's stability. Electromechanical oscillations can be classified in four main categories:

* Local oscillations: Their frequencies typically range from 0.8 to 4.0 Hz.
* Interplant oscillations: Frequencies can vary from 1 to 2 Hz.
* Interarea oscillations: Frequencies are typically in a range of 0.2 to 0.8 Hz.
* Global oscillation: The frequency of such a global mode is typically under 0.2 Hz.

The need for effective damping of such a wide range, almost two decades, of electromechanical oscillations motivated the concept of the multiband power system stabilizer (MB-PSS). IEEE type model of MB-PSS is shown in the Fig. 7

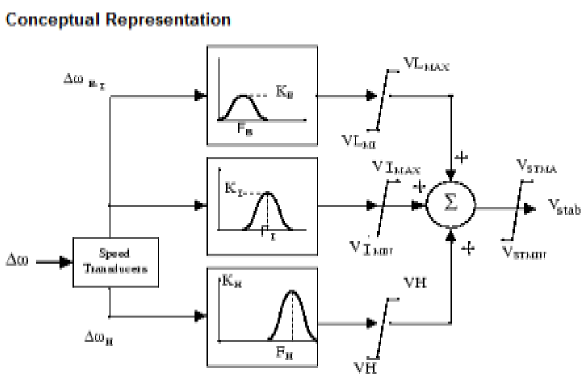

Fig. 7. IEEE type model of MB-PSS

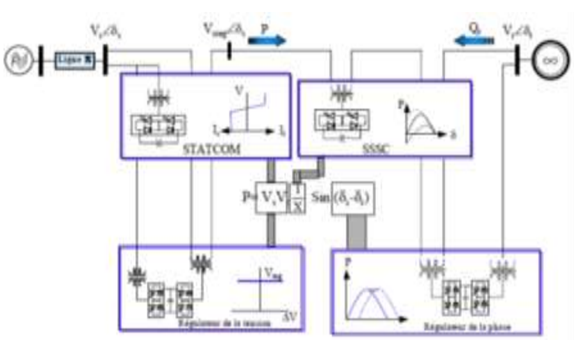

Fig. 8. Active power and it control with FACTS devices

III. SIMULATION

We have taken two generating unit 1000MW and 5000MW respectively, connected with 700KM long transmission line. The initial power output of the SM1 and SM2 are 0.95 and 0.8 respectively. In the above model a single and three phase fault occurs at sending end bus between t= [0.1 0.2] s

A. Simulation result for single phase fault FACTS –PSS

Rotor angle difference between two machines for different coordinated systems UPFC-PSS, STATC-PSS, SSSC-PSS, and SVC-PSS is shown in the Fig-9

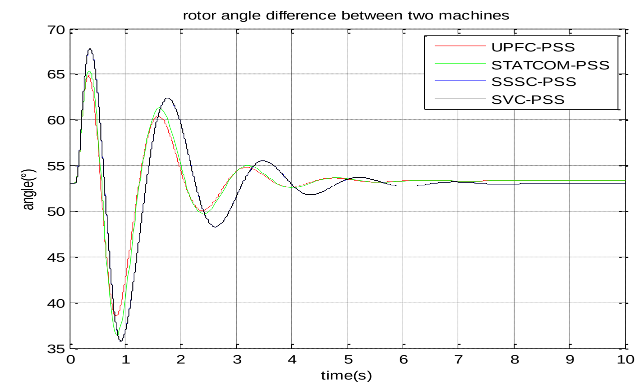

Fig. 9. Rotor angle difference between two machines

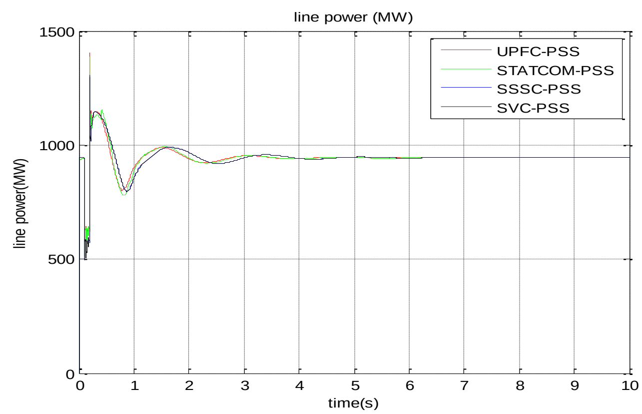

Fig. 10. Line power with FACTS-PSS

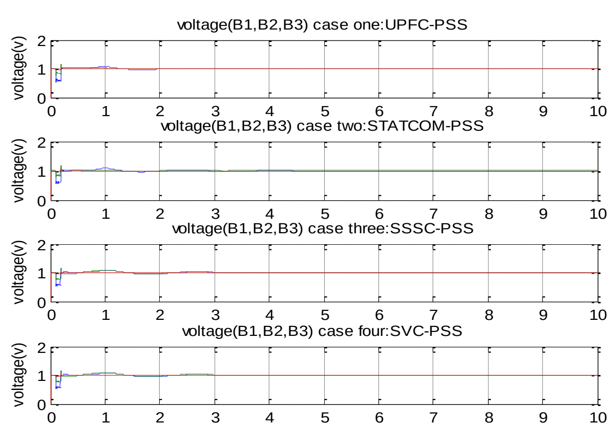

Fig. 11. Voltage of Bus1, Bus2, Bus3

B. Simulation result for single phase fault FACTS-MBPSS

In this case, we use the coordination of FACTS-MBPSS

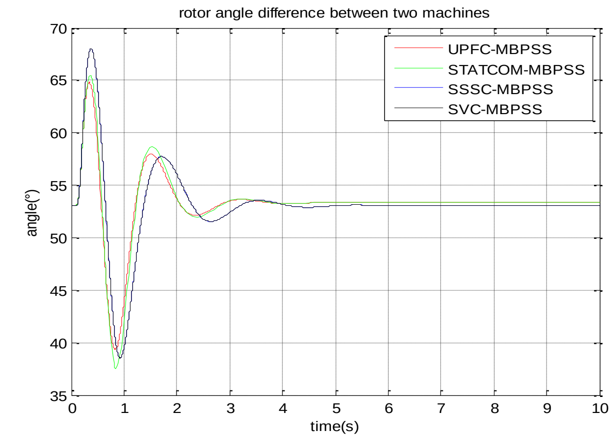

Fig. 12. Rotor angle difference between two machines

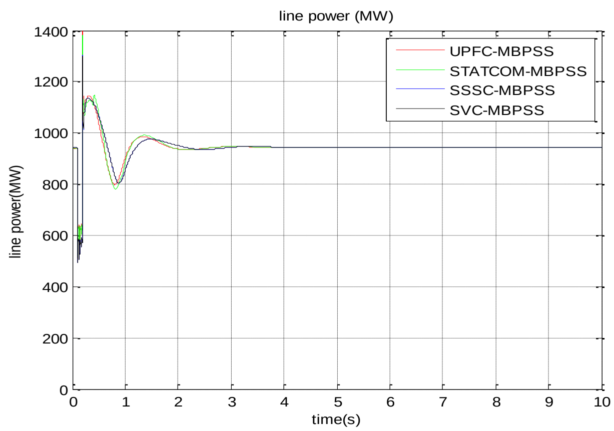

Fig. 13. Line power with FACTS-PSS

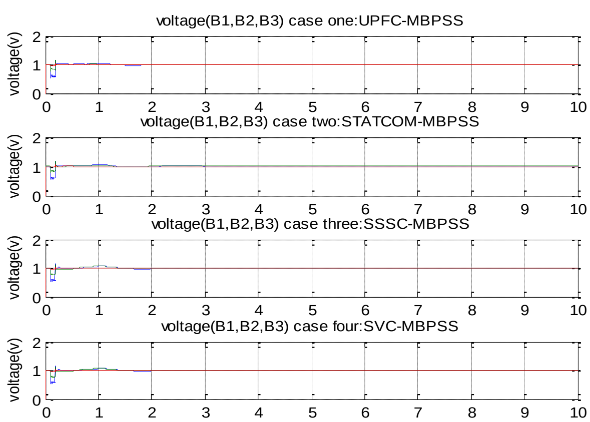

Fig. 14. Voltage of Bus1, Bus2, Bus3

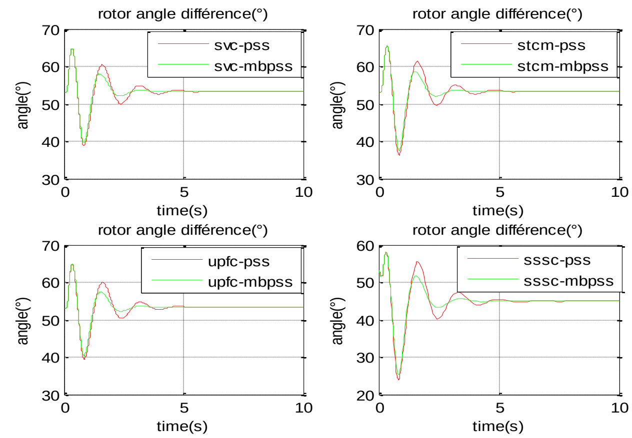

Fig. 15. Comparison between PSS and MBPSS with FACTS devices

D. Simulation result for three phase fault using FACTS-PSS

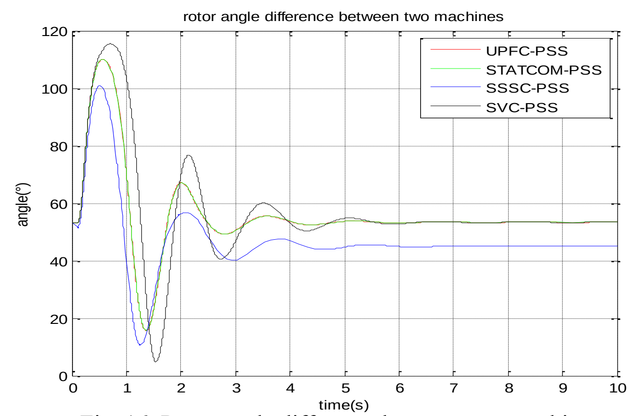

Fig. 16. Rotor angle difference between two machines

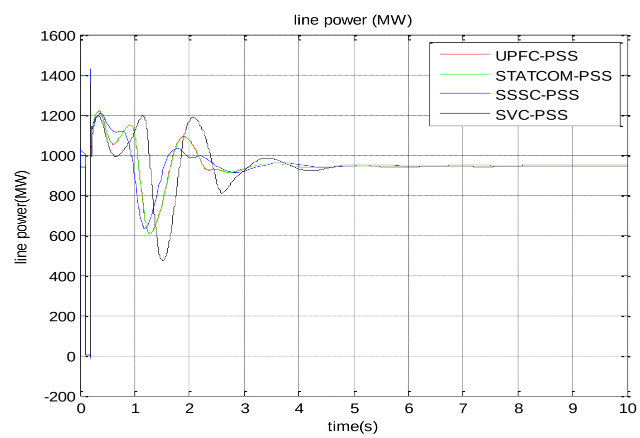

Fig. 17. Line power with FACTS-PSS

C. Comparison between PSS and MB-PSS in the presence of FACTS devices

In the case of single phase fault, the power system is stable with only PSS or MB-PSS, and we used the FACTS devices as an additional controller.

In the case of three phase fault, the PSS and MBPSS fail to maintain the stability of the system. So we use the FACTS devices as compensators.

The simulation results proved the efficiency and robustness of the proposed coordination such as UPFC-PSS, STATCOM-PSS, SSSC-PSS, SVC-PSS and UPFC-MBPSS, STATCOM-MBPSS, SSSC-MBPSS, SVC-MBPSS for improving the several stability of the studied system.

For each case we present the angle difference between too machines, line power transported and the voltage deviation in the buses.

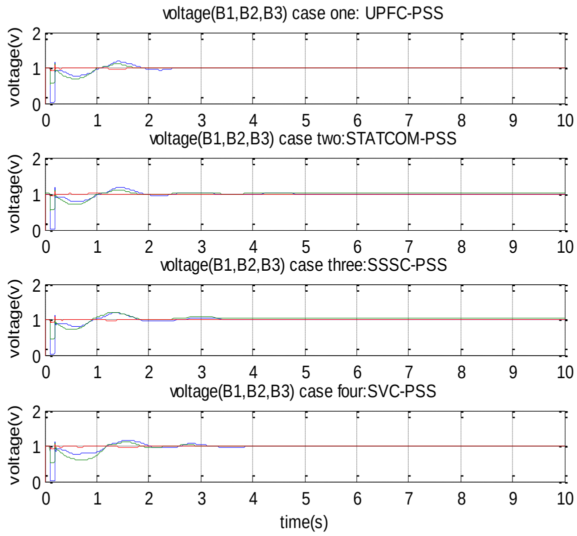

Fig. 18. Voltage of bus1, bus2, bus3

E. Simulation result for three phase fault using FACTS-MBPSS

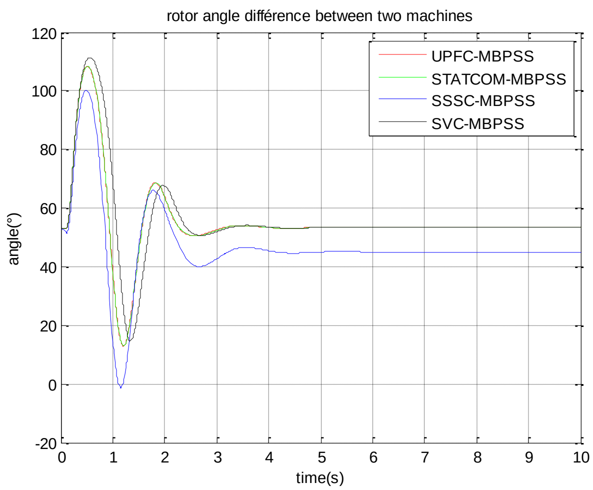

Fig. 19. Rotor angle difference between two machines

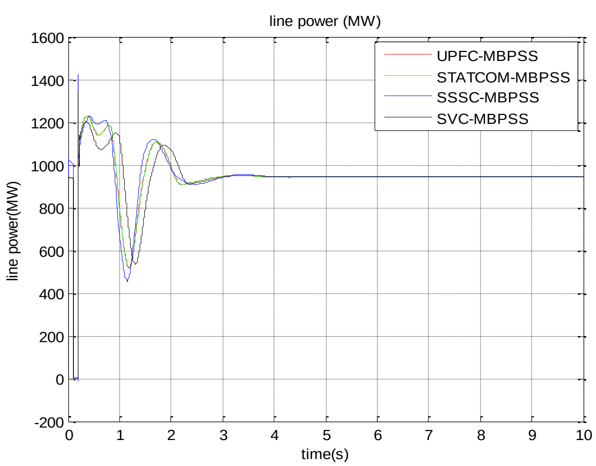

Fig. 20. Line power with FACTS-MBPSS

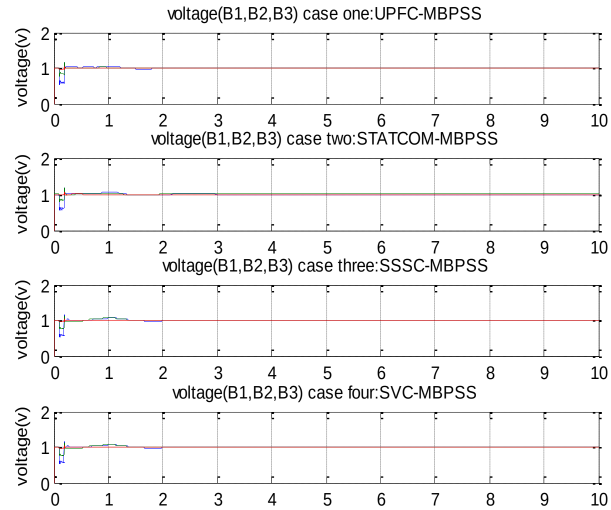

Fig. 21. Voltage of bus1, bus2, bus3

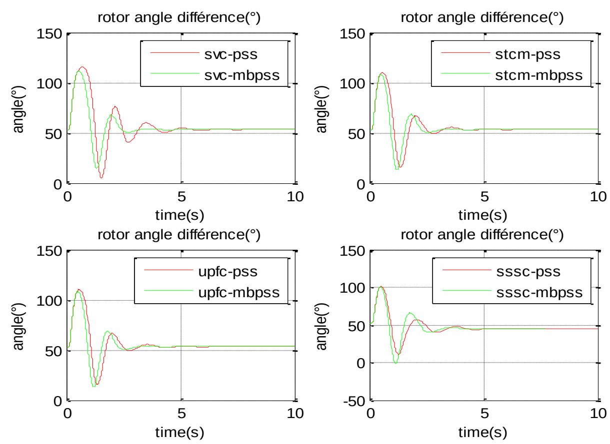

Fig. 22. Comparison between PSS and MBPSS with FACTS devices.

F. Comparison between PSS and MB-PSS in the absence of FACTS devices

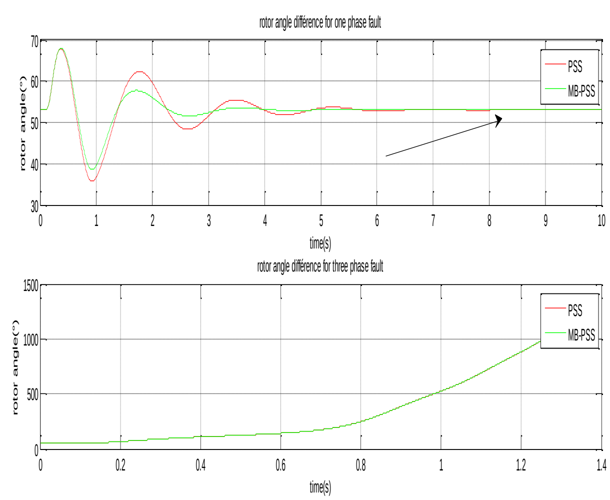

Fig. 23. Rotor angle difference between two machines in case of one phase fault and three phase fault respectively

Table 1. Observation for one phase fault

	PSS					MB-PSS				
	PSS	SVC -PSS	STCM-PSS	SSSC-PSS	UPFC-PSS	MB-PSS	SCV-MBPSS	STCM-MBPSS	SSSC-MBPSS	UPFC-MBPSS
Stable time(s)	7.8	7.5	5.3	5.3	5.2	4.5	4	3.5	4	3.4
Angle(°)	53	53	54	53	54	53	53	54	53	54

Table 2. Observation for three-phase fault

	PSS					MB-PSS				
	PSS	SVC -PSS	STCM-PSS	SSSC-PSS	UPFC-PSS	MB-PSS	SCV-MBPSS	STCM-MBPSS	SSSC-MBPSS	UPFC-MBPSS
Stable time(s)	ns	5.5	4	5	4	ns	3.5	3.5	4	3.4
Angle(°)	ns	52	52	45	52	ns	52	52	45	52

Table 3. Performance of various FACTS devices

	VARIOUS FACTS			
	SVC	STATCOM	SSSC	UPFC
Voltage control	+++	+++	+	+++
Angle deviation control			++	+++
Power oscillation control	++	+++	++	+++

IV. Discussion

The objective of this study was to analyse power system stabilizer, multiband power system stabilizer and coordinated model of FACTS-PSS and FACTS-MBPSS devices performance under several perturbations. The FACTS devices are simulated for the transient stability on a to area power system. The system is simulated by initiating a single-phase fault and three-phase fault near the first machine in the absence of FACTS devices. In this case the difference between the rotor angles of two machines is increased enormously and eventually loses its synchronism (Fig 23). But, when the same faults are simulated in the presence of FACTS devices the system becomes stable (Fig 19, 20, 21). From the Simulink result, it is shown that UPFC-MBPSS is the best one to suppress the one phase fault and three-phase fault in two-area power system.

V. CONCLUSION

This Paper deals with applications of the SVC, STATCOM, SSSC and UPFC. The phasor models of the FACTS devices were implemented and tested in MATLAB/SPS environment. The effects of FACTS (SVC, STATCOM, SSSC and UPFC) installed in electrical power system are analyzed in this paper, and the conclusions are as follow:

The STATCOM and SSSC gives superior performance than SVC for power measurement, bus voltages and rotor angle of the multi-machine system. But the UPFC gives the better result than STATCOM, SSSC and SVC.

The best performance has been obtained by introducing FACTS devices such as SVC, SSSC, STATCOM, and UPFC which compensate reactive power, it's concluded that by introducing FACTS device system performance, voltage stability and transmission capability improves considerably.

The system is simulated by initiating a single phase fault and three phase fault near the first machine in the presence of the coordinated systems FACTS-PSS and FACTS-MBPSS , In this case the system becomes stable. From the simulation results it is shown that the coordination UPFC-MBPSS is the best one to suppress the three phase fault so the best combination for suppressing the three phase fault in two area power system is multiband power system stabilizer and unified power flow controller when the tuning is in appropriate manner.

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